

CLAIMS

What is claimed is:

1. A guidable reamer assembly for use in horizontal directional drilling operations, the reamer assembly comprising:

a cutting member having a central longitudinal axis;

a support member having a central longitudinal axis;

5 a movable shaft; and

a steering assembly moveable between a steering position and a non-steering position in response to rotation of the movable shaft;

10 wherein the steering assembly is adapted to laterally offset the central longitudinal axis of the cutting member from the longitudinal axis of the support member when the steering assembly is in the steering position .

2. The guidable reamer assembly of claim 1 further comprising an outer eccentric cam and an inner eccentric cam supported by the steering assembly; wherein the inner eccentric cam is disposed within the outer eccentric cam; and wherein the movable shaft is operatively connected to the inner eccentric cam.

3. The guidable reamer assembly of claim 2 wherein the steering assembly further comprises a housing adapted to support the outer eccentric cam and the inner eccentric cam therein.

4. The guidable reamer assembly of claim 3 further comprising a beacon assembly supported by the outer eccentric cam and adapted to sense the orientation of the outer eccentric and to transmit a signal indicative of the orientation of the outer eccentric cam.

5. The guidable reamer assembly of claim 3 wherein the movable shaft is adapted to move axially and rotate, wherein the housing and the outer eccentric cam comprise a

clutch operable in response to axial movement of the movable shaft to fix the outer eccentric cam within the housing to prevent rotation of the outer eccentric cam when the movable shaft is rotated.

6. The guidable reamer assembly of claim 1 wherein the support member is radially expandable.

7. The guidable reamer assembly of claim 1 wherein the support member supports the steering assembly.

8. The guidable reamer assembly of claim 1 wherein the support member comprises:

a frame; and

a plurality of borehole engaging members supported by the frame;

wherein the borehole engaging members are adapted to limit rotation of the support member within the borehole.

9. The guidable reamer assembly of claim 8 comprising an actuator supported by the frame and adapted to move the borehole engaging member to a borehole engaging position.

10. The guidable reamer assembly of claim 9 wherein the actuator comprises a hydraulic cylinder adapted to move the borehole engaging member to the borehole engaging position.

11. The guidable reamer assembly of claim 9 wherein the steering assembly comprises at least an actuator supported by the frame and adapted to exert radial force on at least one of the borehole engaging members when in the steering position.

12. A horizontal directional drilling system used to make a generally horizontal borehole, the system comprising:

a rotary drive system;

a drill string having a first end and a second end;

5 wherein the first end of the drill string is operatively connected to the rotary drive system;

a guidable reamer assembly comprising:

a cutting member having a central longitudinal axis and being operatively connectable with the drill string for rotation therewith;

10 a support member having a central longitudinal axis;

a steering assembly moveable between a steering position and a non-steering position and adapted to laterally offset the central longitudinal axis of the cutting member from the longitudinal axis of the support member when the steering assembly is in the steering position.

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13. The horizontal directional drilling system of claim 12 wherein the drill string comprises an outer member and an inner member, wherein the inner member is disposed within the outer member and movable independently of the outer member.

14. The horizontal directional drilling system of claim 13 wherein the cutting member is operatively connectable with the outer member of the drill string for movement therewith.

15. The horizontal directional drilling system of claim 14 wherein the outer member of the drill string is rotatable and wherein operation of the cutting member is driven by rotation of the outer member.

16. The horizontal directional drilling system of claim 13 wherein the steering assembly is operatively connected to the inner member of the drill string, and wherein movement of the inner member drives operation of the steering assembly.

17. The horizontal directional drilling system of claim 16 wherein the steering assembly comprises:

a housing; and

a shaft having a first end and a second end;

5 wherein the first end of the shaft is operatively connectable to the inner member of the drill string, and wherein the second end of the shaft is supported within the housing; and

wherein movement of the inner shaft moves the steering assembly between the steering position and the non-steering position.

18. The horizontal directional drilling system of claim 17 further comprising an outer eccentric cam and an inner eccentric cam supported within the housing; wherein the inner eccentric cam is disposed within the outer eccentric cam; and wherein the inner eccentric cam is operatively connected to the inner shaft.

19. The horizontal directional drilling system of claim 18 further comprising an beacon assembly supported by the outer eccentric cam and adapted to sense the orientation of the outer eccentric and transmit a signal indicative of the orientation of the outer eccentric cam.

20. The horizontal directional drilling system of claim 18 wherein the housing and the outer eccentric cam comprise a clutch operable to fix the outer eccentric cam within housing to prevent rotation of the outer eccentric when the inner shaft is moved.

21. The horizontal directional drilling system of claim 13 wherein the support member is radially expandable.

22. The horizontal directional drilling system of claim 12 wherein the support member supports the steering assembly.

23. The horizontal directional drilling system of claim 12 wherein the support member comprises:

a frame; and

a plurality of borehole engaging members supported by the frame;

5 wherein the borehole engaging members are adapted to limit rotation of the support member.

24. The horizontal directional drilling system of claim 23 comprising an actuator supported by the frame and adapted to move the borehole engaging member to a borehole engaging position.

25. The horizontal directional drilling system of claim 23 wherein the actuator comprises a hydraulic cylinder adapted to move the borehole engaging member to the borehole engaging position.

26. The horizontal directional drilling system of claim 23 wherein the steering assembly comprises at least an actuator supported by the frame and adapted to exert radial force on at least one of the borehole engaging members.

27. The horizontal directional drilling system of claim 12 wherein the drill string comprises a plurality of pipe sections, each pipe section comprising a hollow outer member and an inner member, wherein the outer member has a pin end and box end correspondingly threaded for connection with the pin and box ends of adjacent pipe sections,
5 wherein the inner member has a geometrically-shaped pin end and box end for connection with the pin and box ends of adjacent pipe sections, wherein the cutting member comprises an end correspondingly threaded for connection with the adjacent end of the outer member of the

adjacent pipe section of the drill string, and an inner shaft supported by the cutting member, the inner shaft comprising a geometrically shaped end slidably engageable with the adjacent end of
10 the inner member of the adjacent pipe section of the drill string.

28. The horizontal directional drilling system of claim 12 wherein the drill string further comprises:

a housing; and

a beacon assembly supported by the housing;

5 wherein the beacon assembly is adapted to sense the orientation of the housing
and to transmit a signal including the orientation of the housing.

29. A method for reaming a borehole with a horizontal directional drilling system using a reamer assembly that comprises a cutting member having a central longitudinal axis and a support member having a central longitudinal axis, the method comprising:

sensing a deviation in the borehole;

5 laterally displacing the longitudinal axis of the cutting member relative to the longitudinal axis of the support member to remove the deviation from the borehole; and

rotating and axially advancing the cutting member.

30. The method of claim 29 wherein the guidable reamer assembly further comprises a beacon assembly and wherein the method further comprises sensing the orientation of the deviation with the beacon assembly before the cutting member reaches the deviation.

31. The method of claim 29 wherein the method further comprises positioning the reamer assembly by advancing, withdrawing, or rotating the cutting member.

32. The method of claim 29 wherein the reamer assembly comprises a steering assembly movable between a steering position and a non-steering position and wherein the laterally displacing step comprises moving the steering assembly between the non-steering position and the steering position.

33. A horizontal directional drilling system comprising:
a rotary drive system;
a drill string having a first end and a second end;
wherein the first end of the drill string is operatively connected to the
5 rotary drive system;
a guidable reamer assembly comprising:
a cutting member having a central longitudinal axis and being
operatively connectable with the drill string for rotation
therewith;
10 a steering assembly having a central longitudinal axis, moveable
between a steering position and a non-steering position and
adapted to laterally offset the central longitudinal axis of
the cutting member from the longitudinal axis of the
steering assembly when in the steering position.

34. The horizontal directional drilling system of claim 33 wherein the
drill string comprises an outer member and an inner member, wherein the inner member
is disposed within the outer member and movable independently of the outer member.

35. The horizontal directional drilling system of claim 34 wherein the
cutting member is operatively connectable with the outer member of the drill string and
wherein operation of the cutting member is driven by rotation of the outer member.

36. The horizontal directional drilling system of claim 34 wherein the
steering assembly is operatively connected to the inner member of the drill string, and
wherein movement of the inner member drives operation of the steering assembly.

37. The horizontal directional drilling system of claim 35 wherein the steering assembly comprises:

a housing; and

a shaft having a first end and a second end;

5 wherein the first end of the shaft is operatively connected to the inner member of the drill string, and wherein the second end of the shaft is supported within the housing; and wherein movement of the shaft moves the steering assembly between the steering position and the non-steering position.

38. The horizontal directional drilling system of claim 36 further comprising an outer eccentric cam and an inner eccentric cam supported within the housing; wherein the inner eccentric cam is disposed within the outer eccentric cam; and wherein the inner member is operatively connected to the inner shaft.

39. The horizontal directional drilling system of claim 37 further comprising a beacon assembly supported by the outer eccentric cam and adapted to sense the orientation of the outer eccentric and transmit a signal indicative of the orientation of the outer eccentric cam.

40. The horizontal directional drilling system of claim 38 wherein the housing and the outer eccentric cam comprise a clutch operable to fix the outer eccentric cam within housing to prevent rotation of the outer eccentric when the inner shaft is moved.

41. The horizontal directional drilling system of claim 33 comprising a support member adapted to support the steering assembly.

42. The horizontal directional drilling system of claim 33 comprising a support member having a central longitudinal axis collinear with the central longitudinal axis of the steering assembly, the support member comprising:

a frame; and

5 a plurality of borehole engaging members supported by the frame;

wherein the borehole engaging members are adapted to limit rotation of the support member.

43. The horizontal directional drilling system of claim 41 comprising an actuator supported by the frame and adapted to move the borehole engaging member to a borehole engaging position.

44. The horizontal directional drilling system of claim 43 wherein the actuator comprises a hydraulic cylinder adapted to move the borehole engaging member to the borehole engaging position.

45. The horizontal directional drilling system of claim 41 wherein the steering assembly comprises at least an actuator supported by the frame and adapted to exert radial force on at least one of the borehole engaging members.

46. The horizontal directional drilling system of claim 33 wherein the drill string further comprises:

a housing; and

a beacon assembly supported by the housing;

5 wherein the beacon assembly is adapted to sense the orientation of the housing and to transmit a signal including the orientation of the housing.

47. A horizontal directional drilling system comprising:
a rotary drive system;
a drill string having a first end and a second end;
wherein the first end of the drill string is operatively connected to the
rotary drive system;
wherein the drill string comprises a moveable hollow outer member and
an inner member positioned longitudinally therein, and wherein the
inner member is independently rotatable of the outer member;
a guidable reamer assembly operatively connected to the second end of the
drill string, the guidable reamer comprising:
a cutting member operable in response to rotation of the inner
member of the drill string; and
a steering assembly operable in response to movement of the outer
member of the drill string.

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48. A guidable reamer assembly for use in horizontal directional drilling operations, the reamer assembly comprising:

a cutting member having a central longitudinal axis;

a support member having a central longitudinal axis;

5 a steering assembly moveable between a steering position and a non-steering position and adapted to laterally offset the central longitudinal axis of the cutting member from the longitudinal axis of the support member when the steering assembly is in the steering position.